Diesel Fuel Injector Nozzle Temperature Test Procedure

1 Scope

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This test is used to indirectly determine the peak fuel injector nozzle temperatures associated with two different operating conditions: rated power and exhaust braking at maximum engine speed. Extended exposure to high temperatures can cause the injector nozzles to anneal and soften, resulting in reduced injector life. Two steady-state test procedures are included in this document to evaluate the two aforementioned conditions. Ideally, an instrumented injector nozzle should be used to determine the nozzle temperature directly. However, this is not always practical so this procedure can be used as a substitute to instrumented injector testing.

1.2 Foreword. The Rated Power test is a steady-state test that alternates between nominal coolant temperature and maximum coolant temperature at rated engine speed and 100% pedal. The Exhaust Braking test is a steady-state test that alternates between a moderate speed/load firing point and exhaust braking at maximum engine speed (as calibrated in the vehicle). After testing, the injectors must be carefully handled and returned to the supplier for an investigation. The nozzle shaft hardness should be compared with the nozzle seat hardness to determine how much the nozzle seat softened. The post-test measured nozzle hardness should not be less than the hardware durability limit. If the relationship between annealing temperature (for the 10 h test duration) and nozzle hardness decrease is known, a nozzle temperature can be calculated.

The procedure described in this document does not correlate to a specific amount of vehicle mileage or a percentage of vehicle useful life. It is a risk assessment test for the fuel injectors.

1.3 Applicability. This test was developed for direct-injection diesel applications, and may not be appropriate for other applications. The Exhaust Braking Test is only appropriate for engines equipped with an exhaust brake feature.

Note: Nothing in this specification supersedes applicable laws and regulations unless specific exemption has been obtained.

1.4 Security. Except as noted in the following list, none of the text, procedures, tables, or numbers in this document may be released outside General Motors. If a company outside General Motors is to conduct testing based on this procedure, the following information **may** be released:

- The required content of the test (how many hours/cycles, the speeds, the temperatures, etc.,) or a separate document which gives this information.
- The test reliability (and associated confidence) to be demonstrated on the test.
- Recommendations for continued testing for failure and for analysis of the results.
- Requirements for reporting the test results to GM.

Information about how the test reliability was determined **may not** be released. For example, background on how the test inputs were selected (such as the customer severity being represented) or the field reliability that corresponds to the required test reliability, **may not** be released. Information about how the life goal, speeds, or temperatures were determined **may not** be released.

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2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

SAE J1349

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- PT Lab Oil Drain and Weigh Procedure
- Subsystem Technical Specifications (SSTS)
- Vehicle Technical Specifications (VTS)

Note: This data may change during an engine program or from model year to model year. Make sure the data is kept current.

3 Resources

3.1 Facilities. Major Facility: Engineering Test Laboratory.

3.2 Equipment.

3.2.1 Dynamometer. Suitably rated for the speed range and torque output of the test conditions. Motoring capability is not required.

3.2.2 Propshaft. Suitably matched to inertia and torque output of the engine, inertia of the dynamometer being used, and the maximum speed of the test.

3.2.3 Pedal Position Actuator. Used for automatic pedal control.

3.2.4 Dynamometer Controller. To manage engine speed, engine load/pedal position per the test cycle.

3.2.5 Coolant Cooling System. It must incorporate the following features:

- A closed system with vehicle equivalent flow restriction.
- A sight glass to visually monitor coolant condition.
- Production equivalent by-pass loops (e.g., heater, oil cooler, internal, etc.)
- Other vehicle equivalent features (e.g., overflow/pressure bottle, etc.)
- Cooling system components should have proper relative orientations to allow appropriate air purging, etc.
- The maximum system pressure is to be equal to vehicle radiator cap relief pressure.

Note: External pressurization of the coolant system is not appropriate unless the design of the system prevents the attainment of minimum vehicle pressure levels at equivalent engine speed/coolant temperature conditions.

3.2.6 Oil Cooling System. With vehicle equivalent flow restrictions. Internal engine oil flow is not to be disrupted. The quantity of oil in the oil cooler should be kept to a minimum so that the oil quality degradation rate will not be affected. All test sites must duplicate the oil cooling method used at the design test site for a given family of engines. At start of test (SOT) or fluid change, the whole system should have new oil.

Note: Oil cooling may not be necessary, depending on the application.

3.2.7 Temperature Controllers. To maintain oil, coolant, and fuel temperatures per 4.2.2.1 thru 4.2.2.3.

3.2.8 Exhaust System. Capable of providing vehicle equivalent backpressure. See 3.3.7. Diesel Particulate Filter (DPF) regenerations and other operating modes can impact the test results, so a full vehicle exhaust system is not recommended.

3.2.9 Fuel Delivery System. Capable of maintaining production (intent) vehicle pressure and flow. A fuel flow meter is required to measure actual fuel consumption during the test. A heat exchanger is required to cool the return fuel to the fuel supply temperature specification in 4.2.2.3.

3.2.10 Instrumentation. As needed to measure the parameters found in Section 5.1.

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3.2.11 Automatic Data Acquisition Equipment. Must be capable of a 1 Hz minimum raw signal sample rate and be able to average raw signal values into data for recording (see Sections 5.1 and 5.1.2.1).

3.2.12 Intake Air Condition. Provisions for maintaining the intake air specifications in 4.2.1.

3.2.13 Fuel Sample Valve. An extraction valve in the injector return loop is required to sample the test fuel per 4.3.5. See Figure A3 for a detailed schematic of the extraction location.

3.3 Test Vehicle/Test Piece.

3.3.1 Engine. All pre-durability measurements prescribed by the Design/Release Engineer(s) must be made and recorded in the Engine Build Room (unless plant built). The engine should be broke-in prior to beginning any test cycle tuning/slaving, and a power run (using SAE J1349, or similar) should be completed after the engine break-in. The oil and oil filter should be changed following the break-in and power run procedures.

3.3.2 Short-Belt Accessory Drive System. Full accessory drive system is not required.

3.3.3 Production Engine Control Module (ECM). Hardware and software/calibration for electronically managed engine controls may be required. The engine calibrations are to be the same as used in the vehicle or at least the latest available level during a development program. Calibration changes should only be made if absolutely necessary. Changes should be documented. Non-engine codes (e.g., transmission, Vehicle Anti Theft System (VATS), etc.,) may need to be masked and routines that affect engine performance for non-engine related reasons (e.g., torque management, traction control, etc.,) should be disabled.

3.3.4 Engine Fluids. Factory fill production (intent), for model year of system being tested, engine oil should be used. Use factory source coolant at the as released mix (typically 50/50) for the model year of the system being tested. The use of coolant supplement pellets is not recommended since they may hide design/quality flaws. Primary vehicle specified fuel type should be used. If the test is to be run more than once, alternative fuels can be used (e.g., biodiesel, etc.)

3.3.5 Induction Hardware. Use production (intent) hardware with a complete induction system.

3.3.6 Thermostat. Use a pinned open thermostat.

3.3.7 Exhaust. Use production (intent) exhaust manifold(s). DPF regenerations and other operating modes can impact the test results, so a full vehicle exhaust system is not recommended.

3.4 Test Time.

Calendar time:	Varies days
Test hours:	Varies hours
Coordination hours:	Varies hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Sample Preparation.

4.1.1.1 Mount the engine with associated test material from Section 3.3 in the dyno test cell. Use production (intent) mounts if possible. Mount engine using the appropriate vehicle installation angles.

4.1.1.2 Connect the exhaust system to the engine. Set exhaust back pressure to approximate vehicle back pressure.

4.1.1.3 Connect the air filter housing to the engine. It should contain a new air filter element. The induction system should be orientated the same way as found in the vehicle.

4.1.1.4 Rinse/purge the facility fuel lines with the test fuel prior to connecting the fuel lines to the engine. Change all facility fuel filters if they have been exposed to a fuel that is different from the test fuel. Change the engine fuel system and filter if they have been exposed to fuel that is different from the test fuel. Repeat this step every time the test fuel is changed.

4.1.1.5 Connect the pedal position actuator to the engine.

4.1.1.6 Connect the coolant and oil conditioning systems per 3.2.5 and 3.2.6.

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4.1.1.7 Fill the coolant cooling system with fresh factory-fill coolant per 3.3.4.

Note: Vacuum-fill and/or make sure the system is full of coolant without trapped air pockets.

4.1.1.8 If necessary, calibrate the dipstick per the Test Engineer‘s instructions.

4.1.1.9 Fill the engine with factory fill oil to the “FULL” mark (top of operating range). Recheck the oil level after running the engine for a couple of minutes. Adjust if necessary to achieve the “FULL” mark.

4.1.1.10 If the engine has a base timing which is adjustable, then:

- (1) verify the timing mark is at 0 when Piston No. 1 is at top dead center (TDC) (if not, document, then correct) and,
- (2) set the base timing to the nominal production (intent) specification.

4.1.1.11 If adjustable, tension the accessory belt(s) per the production (intent) specification. If not adjustable, then the production (intent) tensioner(s) should be used.

4.1.1.12 Connect the instrumentation to measure the parameters found in 5.1.1.

4.1.1.13 Auxiliary cooling (e.g., with blowers, fans, etc.,) should only be used if it can be demonstrated that component temperatures in the dynamometer environment exceed the maximum temperatures found in the vehicle. Document any parts being cooled or insulated.

4.1.2 Instrument Calibration. Calibrate all instrumentation as required prior to start of test.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Intake Air Temperature. 16 to 38 °C (60 to 100 °F).

4.2.1.2 Intake Air Pressure. 95 to 105 kPa (28 to 31 inches Hg).

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

The rated power engine speed (R) and the maximum allowable engine speed (Nmax) during vehicle exhaust braking, must be known prior to developing the test. Use Appendix sections A1.1 and A1.2 to calculate the test speeds and loads.

4.2.2.1 Coolant Temperature Conditions. The nominal coolant condition for both tests should be the production (intent) thermostat “start to open” temperature +11 ± 3 °C. The maximum coolant temperature condition, used only in the Rated Power test, should be the production (intent) thermostat “start to open” temperature +16 ± 3 °C.

4.2.2.2 Oil Temperature Conditions. The oil sump temperature should be measured. If it is controllable, the engine sump temperature should be regulated to vehicle maximum temperature –17 °C (30 °F) ± 6 °C (10 °F) unless otherwise instructed by the test engineer.

4.2.2.3 Fuel Temperature Conditions. The fuel supply temperature must be controlled to 40 ± 5 °C.

4.3 Instructions.

4.3.1 Break the engine in using the test procedures supplied by the Test Engineer. Complete a power run (SAE J1349, or other) to develop the test cycle operating points and to determine if the engine is producing representative power.

4.3.2 Program the dyno to run the tests and run any/all portions of both tests, as required, to ensure that the schedules will properly function (slave the test).

4.3.3 Change the oil and filter using the Oil Drain and Weigh Procedure. The total oil consumed while the test injectors are installed must be calculated. Analyze a sample of the oil used during break-in to discover any abnormalities.

4.3.4 Install a new set of injectors. Input any/all quantity adjustment factors (e.g., Injection Quantity Adjustment (IQA), injection quantity adjustment) into the calibration, as necessary, to accurately represent engine operation in a vehicle. Use a paint pen to mark each injector with the cylinder number it is installed in.

4.3.5 At the beginning and end of each complete test, and at the beginning and end of each barrel of fuel used, a fuel sample ≥ 100 mL must be taken. The fuel sample must be extracted from the injector return flow, to ensure that the fuel has gone through the compression and heating stages. The samples should be held

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